Possible Ecological Interactions between Small-pelagic and Mesopelagic Fishes in the Kuroshio-Oyashio Transition Zone and Kuroshio Extension in Spring

Horizontal Distribution
Vertical Distribution
Stomach Contents

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Survey Area (Spring)
Lantern Fish Migration: *Myctophum asperum* (left) and *Symbolophorus californiensis* (right)

After Sassa (2001)
Backgrounds and Purpose

- Kuroshio-Oyashio Transition Zone (KOTZ) and Kuroshio Extension (KE) are the key areas for recruitment of sardine, anchovy, and mackerel.

- Mortality of anchovy larvae in KOTZ-KE is mainly caused by predation by black snake mackerel (*Nealotus tripes*).

- Biological interactions between juvenile small pelagics and myctophids may be possible because 1) myctophids are abundant in KOTZ and 2) both are zooplankton feeder.

- Seek for possible interaction between small pelagics and micronectonic mesopelagic fishes in KOTZ.

<table>
<thead>
<tr>
<th>Day</th>
<th>Night</th>
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<tbody>
<tr>
<td><img src="image1" alt="Small pelagics" /></td>
<td><img src="image2" alt="Small pelagics" /></td>
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<td><img src="image3" alt="Meso-pelagics" /></td>
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<td><img src="image5" alt="Mesopelagic" /></td>
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<td><img src="image7" alt="Mesopelagic" /></td>
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Surface Trawl Survey in Kuroshio/Oyashio Transition Zone in Spring since 1996

Net opening diam.: 27m
Towing at: 3.5 knots at night
Typical towing depth: 0-30m

Tansyu Maru (499GT, 1800HP): -1999
Hokuho Maru (664 GT, 2200HP 2000-)
CPUE (kg / 30 min tow) of Japanese Sardine and SST

1996
- Sardine 96
- 100 - 1000

1997
- Sardine 97
- 100 - 1000

1998
- Sardine 98
- 100 - 1000

1999
- Sardine 99
- 100 - 1000

2000
- Sardine 00
- 100 - 1000

2001
- Sardine 01
- 100 - 1000

2002
- Sardine 02
- 100 - 1000

2003
- Sardine 03
- 100 - 1000

2004
- Sardine 04
- 100 - 1000

Emperor Sea Mt.

1000m and 3000m isobath
Survey Index of and Estimated Recruited No.

Sardine (Watanabe et al., 1995)

Fairly good relation indicates early survival is mainly determined after the feeding larvae distributing in Kuroshio and KOTZ.
Catch Weight Composition in 2002 (0-30m depth)

CPUE kg/30m in

- Anchovy adult
- Miscellaneous
- Myctophids (juv.+ad.)
- Sharks
- Anchovy larvae
- Neon flying squid
- Club-hook squid
- Common squid
- Spotted mackerel ad.
- Mackerel larvae
- Sardine
- Chub mackerel ad.

Catch Weight
Composition in 2002
(0-30m depth)
Adult Myctophid Biomass Composition in 2002 and 2003 (0-30m depth)

2002
- Symbolophorus californiensis
- Ceratoscopelus warmingii
- Myctophum asperum
- Diaphus perspicillatus
- others

2003
- Symbolophorus californiensis
- Ceratoscopelus warmingii
- Myctophum asperum
- Diaphus perspicillatus
- others
CPUE (kg / 30 min tow) of Small Pelagic Fishes and Myctophids (juv+ad) in 2000

Sardine (Scomber spp.)

Anchovy (Symphurus californiensis)

Ceratoscopelus warmingii

Myctophum asperum

Diaphus perspicillatus

1000m and 3000m isobath

SST
Size Composition of Small Pelagic Fishes and Myctophids in 2002

- **Symbolophorus californiensis**
  - Juv.
  - ad.

- **Scomber spp.**
  - Juv.

- **Ceratoscopelus warmingii**

- **Myctophum asperum**

- **Diaphus perspicillatus**

**Larvae+Juv. (black) and adults (blue)**
Nighttime Vertical Distribution of Small Pelagics, Myctophids and Black Snake Mackerel in May 1995 at 37N 147E
Black Snake Mackerel *Nealotus tripes* as a Predator
Index of Relative Importance of Diets of Black Snake Mackerel in May 2002

Larvae BSM selectively feeds on anchovy larvae (Kubota, 2003)
Prey Composition of Juvenile Small Pelagic Fishes and Myctophids (Adults & Juveniles) in May 2002

Composition by number

- **Euphausiids**
- **Neocalanus**
- **Eucalanus**
- **Metridia**
- **Pleuromamma**
- **Paracalanus**
- **Corycaeus**
- **Oncaea**
- **CALANOIDA (broken)**
- **Other COPEPODA**
- **Salps**
- **Oikopleura**
- **Oikopleura house**
- **Gelatinous**
- **Eggs of Invertebrates**
- **Fishes**
- **Miscellaneous**
Stomach Contents of Sardine and Prey Availability in Kuroshio Extension during 1997-1998 (Saito et al., 2001)

- Small copepods (<0.8mm BL, *Paracaranus* etc.) are abundant
- Large copepods (*Calanus pacificus* etc.) was less abundant
- Optimum prey size for juvenile sardine (25-40mm BL) is 0.8-1.2mm
- Juvenile sardine (>33 mm BL) selectively fed on large copepods
- Larval sardine (26-31 mm BL) preyed upon small copepods
- Juveniles of both myctophids and small pelagics fed on 0.6-0.9 mm BL *Paracalanus* in KOTZ (our results)
Summary

- Juvenile small pelagics and myctophids (ad.+juv.) horizontally overlap in surface waters (0-30m) of KOTZ in spring.
- Black snake mackerel shift their diet from anchovy larvae, to krill and myctophids with ontogenetic descent.
- *Corycaeus* and *Oncea* (epipelagic) were preyed by juveniles of small pelagics and some juvenile myctophids.
- Krill, *Pleuromamma* and *Metridia* (deil vertical migrants with photophores) were exclusively consumed by myctophids.
- Possible competition for large copepods.
- Further studies are needed for:
  1) competition with juvenile myctophids for epipelagic ZP,
  2) indirect effects of black snake mackerel,
  3) quantitative evaluation.
Spawning Stock Biomass and Recruitment of Sardine and Chub mackerel

\[ R \text{ per SSB} = f(\text{SSB}, \text{SST}) \text{ in key areas} \]

but imperfect
Myctophids: Diel Vertical Migration and Feeding in Oyashio Area (Moku et al., 2000)

Fig. 9. *Diaphus theta*, *Stenobrachius leucopsarus*, and *S. nannochir*. Feeding habits and diel vertical migration patterns of the 3 myctophid fishes in the subarctic and transitional waters of the western North Pacific.
Prey Composition of Juvenile Small Pelagic Fishes and Myctophids (ad.+juv.) in May 2002

**Diagram Description:**
- **Euphausiids:** Various types, including Neocalanus, Eucalanus, Metridia, and others.
- **Neocalanus:** A specific type of Euphausiids.
- **Eucalanus:** Another type of Euphausiids.
- **Metridia:** A type of Euphausiids.
- **Pleuromamma:** A type of Euphausiids.
- **Paracalanus:** A type of Euphausiids.
- **Corycaeus:** A type of Euphausiids.
- **Oncaea:** A type of Euphausiids.
- **CALANOIDA (broken):** A category of copepods.
- **Other Copepoda:** Various types of copepods.
- **Salps:** A type of gelatinous zooplankton.
- **Oikopleura:** A type of gelatinous zooplankton.
- **Oikopleura House:** A type of gelatinous zooplankton.
- **Gelatinous:** General category for gelatinous organisms.
- **Eggs of Invertebrates:** Specific category for egg types.
- **Fishes:** Various types of fish.
- **Miscellaneous:** Other non-specific categories.

**Species Composition:**
- **Chub mackerel**
- **Spotted mackerel**
- **Sardine**
- **Anchovy**
- **Ceratoscopelus warmingii**
- **Notoscopelus japonicus**
- **Notoscopelus resplendens**
- **Symbolophorus californiensis**
- **Diaphus perspicillatus**
- **Mycophum nitidulum**
- **Mycophum asperum**

The diagram shows the composition of different prey types by number for each species.
CPUE (catch weight per a tow) of Small Pelagic Fishes and Myctophids (juv+ad) in 1999

- Sardine Juv.
- Scomber spp. Juv.
- Anchovy larvae
- Symbolophorus californiensis
- Ceratoscopelus warmingii
- Myctophum asperum
- Diaphus perspicillatus

SST

1000m and 3000m isobath